NBSIR 79-1731

A Review of Fire Incidents, Model Building Codes, and Standards Related to Wood-Burning Appliances

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Final Report

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NATIONAL BUREAU OF STANDARDS, Ernest Ambler, *Director*

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LIST OF ABBREVIATIONS

ASTM -- American Society for Testing and Materials

BBC -- Basic Building Code

BOCA -- Building Officials and Code Administrators

CFR -- Center for Fire Research

CPSC -- Consumer Product Safety Commission

DOE -- U.S. Department of Energy

FFACTS -- Flammable Fabrics Accident Case and Testing System

ICBO -- International Conference of Building Officials

NBC -- National Building Code

NBS -- National Bureau of Standards

NEISS -- National Electronic Injury Surveillance System

NFC -- National Fire Codes

NFIRS -- National Fire Incident Reporting System

NFPA -- National Fire Protection Association

SBC -- Standard Building Code

SBCCI -- Southern Building Code Congress International

UBC -- Uniform Building Code

UL -- Underwriters Laboratories, Incorporated

USFA -- United States Fire Administration

A REVIEW OF FIRE INCIDENTS, MODEL BUILDING CODES, AND STANDARDS RELATED TO WOOD-BURNING APPLIANCES

Richard D. Peacock

Abstract

As a part of the Department of Energy program to advance the technology for the utilization of fuel wood as an alternate energy source for applications ranging from single-family dwellings to apartment complexes and small industries, a review is presented of fire incidents and fire deaths attributable to wood-burning appliances. Initiated to establish accident patterns and to determine the risks involved with the use of wood-burning equipment, the survey represents a compilation of approximately 11,800 fire incidents including injuries and deaths associated with solid fuel burning appliances. In addition, a review of model building codes and of test methods currently used to test or certify wood-burning equipment is included to identify priorities for future research in wood-burning safety.

Key words: Accident investigations; chimneys; coal; creosote; fire departments; fire safety; heating equipment; maintenance; stoves; wood.

1. INTRODUCTION

The Department of Energy is pursuing a program to advance the technology for the utilization of firewood as an alternate energy source for space heating and other applications in single-family dwellings, apartment complexes, and small industries. It is important that the potential fire risks associated with these uses be evaluated and that appropriate codes, standards, recommended practices and test methods be developed and implemented to assure an adequate level of fire safety. To this end, the Center for Fire Research (CFR) at the National Bureau of Standards (NBS) has undertaken a project sponsored by the Department of Energy (DOE) to investigate the fire safety of wood-burning appliances. For the purposes of this study, a wood-burning appliance is considered to be either a factory-built room heater or fireplace or a custom-built fireplace which burns wood and is designed for space heating, cooking, water heating and the like.

The project is anticipated to be a multi-year effort with the following objectives for the work during the first year:

- Review the available fire and explosion statistics and the available literature on the use of wood as a fuel;

- Review the methods presently used to test or certify the fire safety of wood-burning appliances by organizations like the National Fire Protection Association, Underwriters Laboratories, Incorporated, and industry groups; and

- Review several representative building codes to identify requirements related to the construction, installation, and use of wood-burning appliances. The literature and codes review should provide valuable information about the fire risks presented by the use of various wood-burning equipment. Based on this literature review, propose an experimental program to develop laboratory data which will contribute to a reduction of the potential fire hazard through revisions to existing codes and standards.

This report presents an initial review of fire accidents and fire deaths attributable to wood-burning equipment. Initiated to establish accident patterns and to determine the types of risks involved with the use of wood-burning appliances, the survey represents a compilation of fire accidents and deaths related to the use of wood-burning equipment. In addition, a review of standards and test methods used to test or certify the fire safety of wood-burning appliances and a review of several model building codes are included. The purpose of this review is to determine the adequacy of existing codes and standards in addressing the risks associated with wood-burning appliances and to identify priorities for future research in wood-heating safety.

2. ACCIDENT DATA SOURCES

Several groups--the National Fire Protection Association (NFPA), the U.S. Fire Administration (USFA) (formerly the National Fire Prevention and Control Administration) and the Consumer Product Safety Commission (CPSC)--maintain data collection systems that provide information on fire-related injuries, deaths and property losses attributable to various products. Information contained within these data collection systems include: time and location of accident; type of accident; nature of injury or property loss; products involved directly and indirectly with the incident; age, sex and health of the victim (if any); and so forth.

In addition, the Flammable Fabrics Accident Case and Testing System (FFACTS) was developed by the National Bureau of Standards to establish priorities for the study and potential regulation of the flammability of fabric products. FFACTS is now a part of the data system maintained by the Consumer Product Safety Commission.

While the majority of the 11,745 fire incidents analyzed came from one data source, it should be recognized that there may be some overlap in the data reported to different sources. Care was taken to separate data sources in the analysis of the fire incidents presented in this study.

2.1 The National Fire Protection Association

An NFPA publication, "Using Coal and Wood Stoves Safely!," presents a study covering the selection, installation, use and maintenance of coal and wood-burning equipment as well as chimney connectors and chimneys [1][1]. Fire hazards associated with solid fuel burning equipment are reviewed along with descriptions of typical fires, deaths and injury incidents associated with wood burning from reports to the NFPA Fire Records Department. While these incidents only represent a very small sample of all fire incidents involving wood-burning appliances and thus cannot be used to project national injury estimates, they are still valuable in determining the nature of accidents involving wood-burning appliances. Eighteen separate incidents of fire injuries and deaths are reported.

2.2 The National Electronic Injury Surveillance System

The National Injury Information Clearinghouse within CPSC maintains information sources "to collect, investigate, analyze and disseminate injury data and information relating to the causes and prevention of death, injury and illness associated with consumer products" [2]. The National Electronic Injury Surveillance System (NEISS), maintained by the National Injury Information Clearinghouse is the primary source of information for the Commission on product-related injuries. The NEISS system gathers data from statistically selected hospital emergency rooms located throughout the country. While these data can be used to make statistically valid projections for injuries nationwide, reports are submitted only on product-related injuries receiving emergency department care [3]. Injuries treated in doctors' offices, at home and through direct hospital admission are not reported through NEISS. Again, however, the data can be used to develop typical scenarios for accidents involving wood-burning equipment. NEISS is comprised of two levels of information. The first level, the surveillance data, includes information on the products involved as well as about the victim and the injury--age, sex, injury diagnosis, body part involved, treatment data, locale, fire or motor vehicle involvement, occupational injury, and whether the victim was treated and released, hospitalized or dead on arrival at the emergency room [4].

In addition, second level, in-depth investigations are conducted to obtain further information on selected cases from the NEISS system to provide details concerning the accident sequence and the cause of injury. Death certificates also supply additional data on consumer product hazards.

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[1] Numbers in brackets refer to the literature references listed at the end of this paper.

A total of 71 in-depth accident investigations from the years 1973-1978 and 96 death certificates on file with CPSC since July 1973 were used in this study in addition to the NEISS estimates of national injury statistics.

2.3 The U.S. Fire Administration

The National Fire Data Center of USFA maintains the National Fire Incident Reporting System (NFIRS), a data system collecting fire incident data from numerous fire departments throughout the country. At the time of this report, a total of 1,038,601 separate fire incident records from 11 states were included. The data represent the calendar years 1975 through 1977 and the first three quarters of 1978. Included in each report are details on the equipment involved, the material first ignited, the nature of the fire growth, the extent of damage including dollar loss estimates and injuries or deaths associated with the fire. A total of 11,534 incidents were attributable to solid fueled heating appliances; this including both coal and wood-burning appliances. No attempts were made to separate coal versus wood-burning appliances. However, it is felt that since many appliances can use both fuels and equipment designs are similar, the accident patterns should be similar.

2.4 The Flammable Fabrics Accident Case and Testing System

The NBS Flammable Fabrics Accident Case and Testing System (FFACTS), now maintained by the Consumer Product Safety Commission, contains data derived from case histories of accidental fires involving fabric items, along with analysis of the actual fabrics involved in the accidents. An earlier report by Hayes of NBS presented the findings of a study of space heater involvement in fabric fires, which included wood heaters [5]. Space heaters of all kinds ranked sixth in the tabulation of direct sources of fabric ignition in the FFACTS file. While space heaters are not a major source of fabric fire injury, in terms of severity of personal injury they appear to achieve some significance. There are twice as many deaths from space heater incidents and additionally twice as many people hospitalized as the average for all FFACTS ignition sources [5]. A total of 127 incidents involving space heaters are reported by Hayes. However, only four involve wood heaters.

2.5 The Massachusetts State Fire Marshal's Office

In an analysis of solid fuel-related fires performed under contract to CFR, Shelton reports on fire records on file with the Massachusetts State Fire Marshal's Office from late 1977 through June 1978 [6]. A total of 104 reports were on file as of June 1978, mostly covering fires which occurred during the 1977-1978 heating season. The reports were analyzed by Shelton to determine the probable cause of each fire. A copy of the report is attached as appendix A.

2.6 The Oregon State Fire Marshal's Office

An analysis of 234 fires occurring in single-family dwellings during the year 1977 reported to the Oregon State Fire Marshal's Office were analyzed to determine the probable cause of the fire [7]. In addition, injuries, deaths and dollar loss are reported for the 234 fires included in the study.

3. FIRE INCIDENTS RELATED TO WOOD-BURNING EQUIPMENT

3.1 Causes of Fire Incidents

An analysis of the data collected from the sources outlined above indicates that a majority of the accidents arise from the unsafe installation and unsafe use of wood-burning equipment. Typical accidents include:

- The use of unvented equipment inside a dwelling;
- The installation of wood-burning equipment too close to combustible framing and furnishings;
- Placement of flammable solids and liquids too close to wood-burning equipment;
- The use of flammable liquids to kindle a fire;
- Overloading of wood-burning equipment leading to operation well beyond design limits;
- The ignition of clothing or other fabrics during loading, unloading, cleaning or use of wood-burning equipment;
- Contact burns received from hot surfaces of wood-burning equipment;
- The use of defective or improper chimneys for wood-burning equipment; and
- The ignition of creosote and carbon deposits on the inside of chimneys leading to very hot chimney fires.

3.2 Incidents Associated with Wood-Burning Appliances

Of the 11,534 residential solid fuel related fire incidents reported in the NFIRS data base, 10,863 or 94% of the fires occurred in one- and two-family dwellings. Only 671 fires occurred in larger residential structures. A dollar loss estimate of property loss was also known for 8,837 of the fires. Figure 1 illustrates the property loss in those cases where there was a loss and the loss was estimated. The loss was under $1,000

in 72% of the fires. However, because of five fires in which the damage was over $250,000, the average dollar loss was $12,700 for all cases in which the dollar loss was known.

A wood-burning system is comprised of two or three essential parts: the wood-burning unit itself, a chimney assembly connected to it, and for free-standing heaters, a chimney connector joining the appliance and the chimney. Figure 2 shows the fires associated with each of these components. The appliance was reported as the equipment involved in 6,300 (55%) of the fires, followed by chimneys in 3,993 (35%) and chimney connectors in 1,241 (10%) of the fires. An analysis of accidents involving these assemblies is described below.

3.2.1 Activities of Persons Involved and Products Involved

The activity of the persons involved in accidents related to wood-heating appliances is a major factor in understanding the risks associated with wood-burning equipment. After review of the accident histories of the cases involving wood-heating equipment, the accidents were broken down into 14 general categories: (1) the ignition of nearby combustible materials including materials placed near equipment, wall and floor surfaces too close to equipment, and building construction with insufficient clearances to prevent ignition; (2) the ignition of the exterior of a structure by sparks released from a chimney; (3) the ignition of creosote and carbon deposits on the inside of chimneys leading to very hot chimney fires; (4) improper fueling or overloading of a wood-burning appliance leading to operation well beyond design limits; (5) equipment malfunction or poor design leading to equipment failure and fire escaping from the firebox; and (6) the use of flammable liquids near a wood-burning appliance or to kindle a fire in an appliance. A small number of other specific causes included (7) the accidental ignition of clothing during loading and unloading of wood-burning appliances; and (8) stove backpuffing, a small explosion which occurs when fuel-rich combustion gases mix with oxygen upon door or air inlet opening. In addition, a number of fires were attributed to less specific causes such as: (9) lack of proper maintenance; (10) equipment design deficiency and improper equipment design; (11) improper equipment operation; (12) the ignition of the dwelling structure; (13) improper installation; and (14) the use of wood-burning appliances with improper or defective chimneys including the use of insulated stovepipe through combustible walls and ceilings and the use of cracked and broken chimneys. A number of cases were also noted where no specific cause could be identified.

Figure 3 and table 1 illustrate the conditions leading to fires involving wood-burning appliances identified from the NFIRS data system. Incidents where product malfunctions or design defects were involved accounted for only 13% of the incidents. Overwhelmingly, conditions related to the installation of the product were responsible for fire accidents. The installation of appliances too close to combustibles or the placing of combustible materials nearby the heating appliance accounted for 21% of the fires. Improper maintenance, including the use

of worn out equipment, accounted for 32% of the fires--together over 50% of the fires where a cause was known. The ignition of the exterior of a building by sparks released from chimneys accounted for 11% of the fires as did the ignition of structures without further details.

Shelton reports similar data from the Massachusetts State Fire Marshal's Office. Roughly three-quarters of the fires reported were attributed to unsafe installations and about one-quarter to unsafe operation and maintenance. He reports only 2% of the fires were attributed to product defects or poor design [6].

In addition, in the analysis of fires reported to the Oregon State Fire Marshal's Office related to solid fuel heating appliances shown in figure 4, only two fires out of 234 were attributed to a defective stove [7]. Roughly three-quarters of the fires were attributed to unsafe installations and one-quarter to improper operation or maintenance.

3.2.2 Age and Sex of Persons Involved

The age and sex were known for 69 out of 100 persons involved in accidents specified in the NEISS files and the NFPA publication "Using Coal and Wood Stoves Safely!" Figure 5 and table 2 show the age and sex distribution of persons involved in wood-heating accidents where the age and sex of the victims were known. Young children were involved more frequently in accidents than other individuals. Persons 10 years old or younger were involved in 35 out of 69 accidents where the age was known. Males outnumbered females in the accidents by a ratio of almost 2:1. Traditional use patterns of wood-burning appliances would support these imbalances. In addition, other factors such as less familiarity with equipment use, in the case of young children, and poorer judgment and reactions in the case of both the young and the old make these people more susceptible to accidental injuries.

3.2.3 Severity of Injury

According to the NFIRS data system, injuries were involved in only 125 out of the 11,534 fires and deaths in only 40. A total of 159 injuries and 65 deaths were recorded for non-fire service persons. For accidents involving injuries, the NEISS data provides information on the severity of injury. Figure 6 shows the extent of injury to persons involved in solid fuel space heating ignition accidents, both wood fueled and other fuels. Many of these injuries were quite serious. Forty-two percent of the accidents involving wood-heating equipment were serious enough to require hospitalization; a total of 19 persons died or 23% of those persons involved.

4. SUMMARY AND CONCLUSIONS FROM FIRE INCIDENT DATA

Space heating, cooling and ventilation equipment account for only 7.5% of all burn injuries according to a recent study prepared for the

Consumer Product Safety Commission [8]. Of these, wood-burning appliances are only a part.

This study was conducted primarily to determine the nature of accidents involving wood-burning appliances. Overwhelmingly, the accidents were related to the installation of wood-burning equipment and insufficient personal attention in its use. From the standpoint of fire safety, the most important areas for concern are:

- The ignition of adjacent combustibles from the heat from wood-burning equipment;

- The ignition of building exteriors by sparks escaping from chimneys; and

- The use of wood-burning equipment with improper, defective, or poorly maintained chimneys and resultant chimney fires.

From this study, fire safety standards for wood-burning equipment should include provisions addressing the following:

- Structural integrity of wood-heating units, tested at conditions typical of actual use;

- Detailed instructions for the installation of equipment including proper chimneys to be used and clearances to combustible surfaces in addition to information warning the consumer of the potential hazards involved with the use of equipment including the use of flammable liquids, the potential for burns from the hot surfaces of the stoves, and possible consequences resulting from overfueling; and

- The use of spark screens on chimney outlets or other means to prevent sparks and glowing embers from escaping from chimneys leading to fires on the building exterior.

5. MODEL BUILDING CODES

Building codes, adopted by local and/or state jurisdictions, regulate the construction of new buildings and the modification of existing buildings. Regulated and enforced by the adopting jurisdiction, the codes are designed to protect occupants and property from fire and insure structural integrity of the building systems. A recent survey indicates that most of the building codes adopted are patterned after one of the four model codes [9].

As a part of this literature study, the four model codes were reviewed to identify requirements related to the construction, installation and use of wood-burning appliances:

- The BOCA Basic Building Code/1978, published by the Building Officials and Code Administrators International, Incorporated [10,11];

- The National Building Code, 1976 Edition, published by the American Insurance Association [12];

- The National Fire Codes, 1978, published by the National Fire Protection Association [13];

- The Standard Building Code, 1976 Edition with 1977 and 1978 amendments, published by the Southern Building Code Congress International, Incorporated [14,15]; and

- The Uniform Building Code, 1976 Edition with 1977 supplement, published by the International Conference of Building Officials [16,17].

All of the above codes contain provisions that regulate the construction and installation of masonry chimneys, masonry fireplaces, factory-built chimneys and factory-built fireplaces, fireplace stoves, room heaters, and other wood-burning appliances. These requirements are described below.

5.1 Chimneys and Chimney Connectors

A chimney used with any wood-burning system serves one important purpose--to vent the heated products of combustion within the heating unit safely to the outside of the building. The proper construction of chimneys and the correct installation of chimney connectors and of factory-built chimneys with proper clearances to combustible materials is particularly important in preventing accidental fires. All of the model building codes reviewed contain provisions governing the construction and installation of both masonry chimneys and factory-built chimneys. Some of the codes also contain provisions covering the construction and installation of chimney connectors. Tables 4 and 5 summarize the code requirements.

5.1.1 Construction

All of the model codes reviewed require that masonry chimneys be constructed of solid masonry units or reinforced concrete with walls not less than 4 in (10 cm) thick or of rubble stone masonry not less than 12 in (30 cm) thick. In addition, all of the model codes reviewed specify that chimneys should be lined with fire-clay flue lining (ASTM C 315), or the equivalent, with a thickness of not less than 5/8 in (1.6 cm), or with a liner of other material that will resist corrosion, softening or cracking from flue gases at temperatures up to 1,800° F (980° C). Flue linings provide additional protection for chimneys from thermal stress and the corrosive effects of hot flue gases [18,19,20]. Actual fire testing on masonry chimneys indicated a greater hazard from unlined chimneys than from lined ones [21].

If multiple flues are included in a single chimney, the codes require that there be a masonry separation at least 4 in (10 cm) thick, bonded into the masonry wall of the chimney to separate each flue passageway.

Obviously, draft is also an important factor in chimney design. The model building codes require that a chimney extend at least 3 ft (8.9 m) above the highest point where they pass through the roof of the building, and be at least 2 ft (0.6 m) higher than any portion of a building within 10 ft (3 m). Insuring sufficient height above the roof will help prevent downdraft and other wind effects.

For factory-built chimneys, the model codes reviewed all require that the chimney be constructed of listed, approved factory-built components installed in strict accordance with the terms of their approval and listing, and the manufacturer's installation instructions. Actual factory-built chimneys are subjected to testing to determine the structural integrity of the chimney and to determine proper clearances to combustible surfaces. The test methods used are described in section 6.

Only two of the model codes, the BOCA Basic Building and Mechanical Codes and the National Fire Codes, contain regulations governing the construction of chimney connectors used to connect a heating appliance to a chimney. The National Fire Codes specify that chimney connectors are to be constructed of factory-built chimney material, Type L vent material, or steel pipe having resistance to corrosion and heat not less than that of galvanized pipe. Minimum thicknesses for connectors are specified depending on the diameter of the pipe. The length of the connector should be as short and as straight as possible [13], with horizontal length less than 75% of the vertical height.

5.1.2 Clearances

Certain minimum clearances between chimneys and chimney connectors and combustible materials must be maintained in order to prevent the ignition of these materials from the heat transmitted from the hot chimney surfaces. All of the model codes reviewed contain requirements for minimum clearances for chimneys. In addition, two of the codes also include clearances for chimney connectors. For masonry chimneys, a clearance of at least 2 in (5 cm) from the outside face of a chimney is required for all headers, beams, joists and studs. Combustible lathing, furring or plaster grounds may, however, be placed against a chimney within 1-1/2 in (3.8 cm) of the corners. The requirements do not apply to chimneys placed entirely on the outside of a building against the sheathing. Factory-built chimneys are installed with clearances as specified in the manufacturer's instructions. Since factory-built chimneys are to be tested and listed by nationally recognized testing laboratories, the clearances specified for these chimneys are based on actual testing. Usually, 2 in (5 cm) of clearance is specified [22].

Clearances from chimney connectors depend on the material of construction. For single wall metal pipe, a clearance of at least 18 in (45 cm)

is required as shown in figure 7. For Type L vent piping, the National Fire Codes allow a clearance of at least 9 in (23 cm). These clearances may be reduced with the use of specific methods of protection as outlined in table 6 and figure 8, to as little as 3 in (8 cm).

Several experimental studies have been carried out to determine minimum allowable clearances to combustible materials. Voigt, in a 1933 publication, recommended a minimum clearance of 12 in (30 cm) for chimney connectors of 9 in (23 cm), in diameter [23]. A more extensive study, performed by Underwriters Laboratories in 1943, presents a number of methods for protecting combustible surfaces [24]. Some of the data from this study is shown in table 7. By comparing tables 6 and 7, the model codes require more conservative limits than the UL testing would indicate necessary. Mitchell [21] recommends a 2 in (5 cm) clearance for masonry chimneys.

5.2 Wood-Burning Units

All the model codes reviewed also provide requirements for the construction and installation of wood-burning firebox units including masonry fireplaces, factory-built fireplaces, factory-built fireplace stoves, and factory-built room heaters. Table 8 summarizes the requirements.

5.2.1 Construction

All of the codes reviewed contain guidelines for the construction of masonry fireplaces. A minimum thickness of 8 in (20 cm) is specified for all structural walls. If a lining of low-duty refractory brick (ASTM C 64), or the equivalent, at least 2 in (5 cm) thick, is provided, the total thickness, including liner should be at least 8 in (20 cm). When such a liner, or other approved liner is not provided, the total thickness of back and side walls should be at least 12 in (30 cm). Two of the model codes reviewed also allow the use of steel fireplace units--a firebox liner of steel at least 1/4 in thick and an air chamber--installed with masonry to provide a total thickness of at least 8 in (20 cm). A minimum of 4 in (10 cm) of solid masonry should be used.

Two of the codes, the Basic Building Code and the Uniform Building Code also include guidelines for fireplace depth. The Basic Building Code specifies the depth of the fireplace to be 20 in (51 cm). The Uniform Building Code specifies a maximum of 20 in (51 cm).

A hearth extension is also required by all of the codes reviewed. The hearth extension, constructed of brick, stone or other noncombustible material, should extend a minimum of 16 in (40 cm), in front of the fireplace opening and at least 8 in (20 cm) on each side of the opening. For fireplaces with an opening of 6 sq ft (0.56 m^2) or more, the extensions required are 20 in (51 cm) in front and 12 in (30 cm) on each side.

As with factory-built chimneys and chimney connectors, factory-built fireplaces, fireplace stoves and room heaters are to be tested and listed by a nationally recognized testing laboratory and installed in accordance with the listing and the manufacturer's instructions. For factory-built fireplaces and fireplace stoves, hearth extensions are to be provided as directed by the manufacturer. Factory-built room heaters are to be sold with directions for the protection of combustible walls and floors, provided by the manufacturer.

5.2.2 Clearances

Minimum acceptable clearances between masonry fireplaces and combustible framing, wall surfaces, and woodwork are included in the model codes. A distance of at least 4 in (10 cm) should be maintained between the fireplace and combustibles. Combustibles should not be placed within 6 in (15 cm) of the fireplace opening. However, if fireplace walls are at least 12 in (30 cm) thick, the facings or trim may be attached directly to the fireplace.

Factory-built fireplaces, fireplace stoves and room heaters are to be installed with minimum clearances as specified by the unit's listing and the manufacturer's instructions.

As with any heat producing appliance, it is important that sufficient clearances be provided between the hot surfaces of the appliance and any combustible materials. Several references are available providing guidelines for minimum clearances. The NFPA Manual on Clearances for Heat Producing Appliances includes recommended minimum clearances for appliances as shown in table 9. Usually, a clearance of 36 in (0.9 m) is recommended. For heaters surrounded by an outer jacket arranged with openings at top and bottom so that air circulates between the walls of the heater [25], clearances of 24 in (61 cm) from the front of the appliance and 12 in (30 cm) from the sides and back of the appliance are recommended [26]. Clearances may be reduced with proper protection as described for chimney connectors in table 6.

Proper clearances are equally important with masonry fireplaces. Tests performed on a particular masonry fireplace [27,28] indicated that safe temperatures are easily exceeded on combustibles in contact with outside surfaces of masonry fireplaces, even when an 8 in (20 cm) thickness of masonry is provided.

6. TEST METHODS

As outlined above, requirements for factory-built chimneys, chimney connectors, fireplaces, fireplace stoves, and room heaters include testing and listing by a nationally recognized testing laboratory. A number of test methods, developed by Underwriters Laboratories, Incorporated, are used for the evaluation of these products. The test methods are:

- UL 103, Chimneys, Factory-Built [30];
- UL 127, Factory-Built Fireplaces [31];
- UL 737, Fireplace Stoves [32]; and
- UL 1482, Room Heater, Solid Fuel Type [33].

In general, the test methods outlined contain similar provisions regulating the design, construction and installation of the appliances. All contain provisions covering:

- Minimum information to be included in installation instructions;
- Materials of construction;
- Performance testing of units in three different fire tests; and
- Structural integrity of materials.
- For room heaters, employing blower assemblies, requirements are included covering safe electrical construction.

The review below will concentrate on the test method for solid fuel room heaters, UL 1482. Many of the provisions outlined below are similar, if not identical in the other UL test methods.

6.1 Installation of Appliances

The August 1978 draft of UL 1482 contains a number of requirements relating to the installation and operation of solid fuel burning room heaters. Information to be included in the manufacturer's instructions accompanying each room heater is required as follows:

- The parts and materials required and the step-by-step process for the installation of a room heater, accessories and its chimney connector;
- The parts or materials for floor protectors including minimum areas covered;
- The size and type of chimney to be used with the room heater;
- Any limitations on installation, minimum clearances or construction;
- The size and material for chimney connectors and its attachment to the chimney and room heater;
- Inspection, maintenance and cleaning of the chimney and chimney connector;

- Minimum clearances for the room heater and chimney connector;
- The safe disposal of ashes;
- Caution against the use of flammable liquids;
- Reference to the formation and removal of creosote buildup in the chimney connector and chimney;
- The use of grates, andirons or other methods to support the fuel;
- Operation and use of manual or thermostatic controls; and
- Operation and use of electrical assemblies.

6.2 Performance Tests

6.2.1 Structural Integrity Tests

UL 1482 contains a number of performance tests to determine the structural integrity of components used in room heaters. If chimney connector sections are supplied with the room heater, they are subjected to a strength test as shown in figure 9.

The connector must not open up, break apart or become damaged when subjected to three impacts from the sandbag pendulum. In addition, the chimney connector must not be damaged when subjected to a 100 lb force applied to parts intended to be field joined.

Room heaters are also subjected to stability tests to insure that the product will not tip over in normal use. The minimum force necessary to tip the unit over and the angle at which it tips is measured.

Glass used as part of a room heater door is subjected to an impact test as shown in figure 10. The glass must withstand the test without breaking or cracking. Glass panels must also withstand a water spray test while heated to be acceptable.

6.2.2 Firing Tests

The UL Standards for factory-built fireplaces, fireplace stoves and room heaters all contain details of three fire tests conducted with the appliance installed in a test enclosure with clearances recommended by the manufacturer (figure 11). The tests, simulating worst case conditions, are:

- A radiant fire test using a 6 in depth of charcoal briquettes maintained for as long as necessary to obtain maximum temperatures;
- A brand fire test using nominal 1 x 1 Douglas fir strips constructed into brands whose dimensions equal two-thirds of the hearth

area of the heater (again, the test is continued until maximum temperatures are reached) ; and

- A flash fire test conducted as a continuation of the brand fire test by placing eight brands at one time in the heater.

Table 10 indicates the maximum temperatures allowable by the UL tests on surfaces of the test enclosure, room heater or chimney connector parts at points of zero clearance to the enclosure and beneath a floor protector.

Maximum temperature rises are also specified for any part of the room heater or chimney connector including electrical assemblies, motors and metals whose failure may cause the product to be unsuitable for use.

7. CONCLUSIONS

The results of a review of fire incidents involving wood-burning appliances presented in this paper indicates that the major risks associated with the equipment are attributed to improper installation of wood-burning appliances and insufficient personal care in their use. Only a small minority of fires were attributed to faulty equipment design or equipment malfunction.

All the model building codes reviewed contain requirements covering the construction of masonry fireplaces and chimneys. Minimum clearances to combustible materials are given for masonry appliances. Requirements for factory-built appliances rely on testing and listing by nationally recognized laboratories. Recommendations for minimum clearances for factory-built appliances adopted by manufacturers are included in recommended practice manuals [26]. Actual clearances are, however, based on testing of the appliances. Clearances to combustibles may be reduced with the use of specific forms of protection for the combustible surfaces. Model Building Code Officials recognized the need for minimum installation instructions in a report prepared under contract to CFR. A copy of the report is attached as appendix B.

Test methods used by laboratories for the listing of wood-burning appliances contain provisions describing stringent material, installation and performance requirements (fire and structural integrity) for factory-built appliances. Fires much larger than normal use are used to simulate "worst case" conditions. These same requirements, applied to a particular masonry fireplace, led to temperatures on nearby combustible surfaces in excess of those deemed acceptable for factory-built units [27,28].

Future research in the area of wood-heating safety should concentrate on the installation and use of wood-burning appliances. Existing criteria for the installation and use of wood-burning appliances are based on data developed over 30 years ago and do not provide information

on many materials available in the current market or allow for any variations based on the use of alternate materials.

Possible areas for future research that may be needed to define appropriate requirements for test methods include:

- Determination of typical firing rates for wood-heating equipment and development of a standardized fuel source for this heat output;
- Study of the potential for ignition of combustible construction and furnishings from the heat generated by wood-burning appliances;
- Study of methods for protecting combustible materials and surfaces from nearby wood-heating equipment; and
- Investigation of creosote formation and deposition in typical situations and conditions leading to ignition in chimney fires.

In addition, the development of a public education program to alert users of wood-burning appliances to the risks involved with the use of the equipment and to provide information on the safe installation of appliances is important to insure that those installing appliances without building permits, etc., have the necessary information available for safe installation and use.

8. ACKNOWLEDGEMENTS

This study was sponsored by the U.S. Department of Energy. The support by DOE, and by the contract officers, Dr. Jorgen Birkeland and Mr. J. Edward Manuel, is gratefully acknowledged. Thanks are also due to Mr. Alan Gomberg and Mr. Stephan Leigh of the Center for Fire Research who provided data from the NFIRS data base of the United States Fire Administration.

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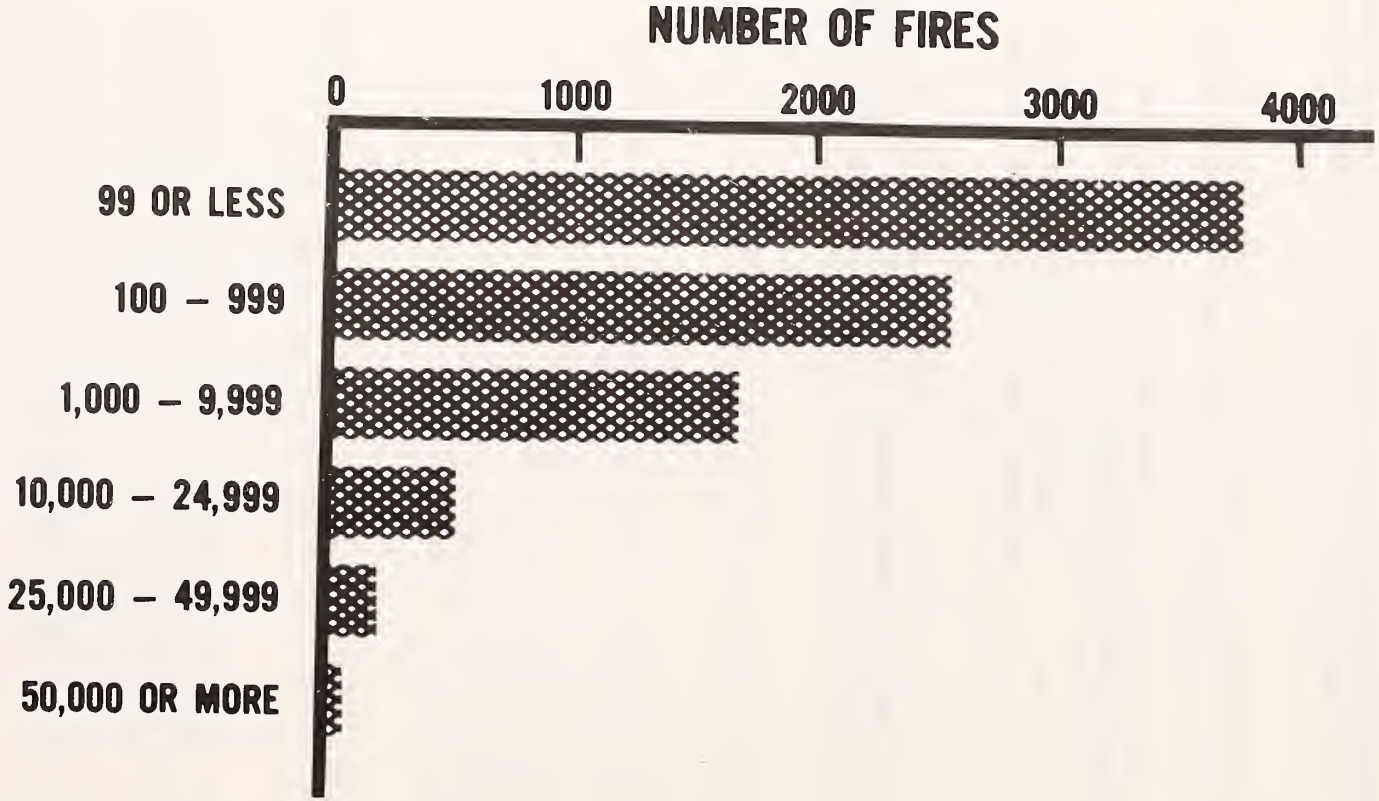

Figure 1. Dollar loss estimates as reported in NFIRS solid fuel fire incident data

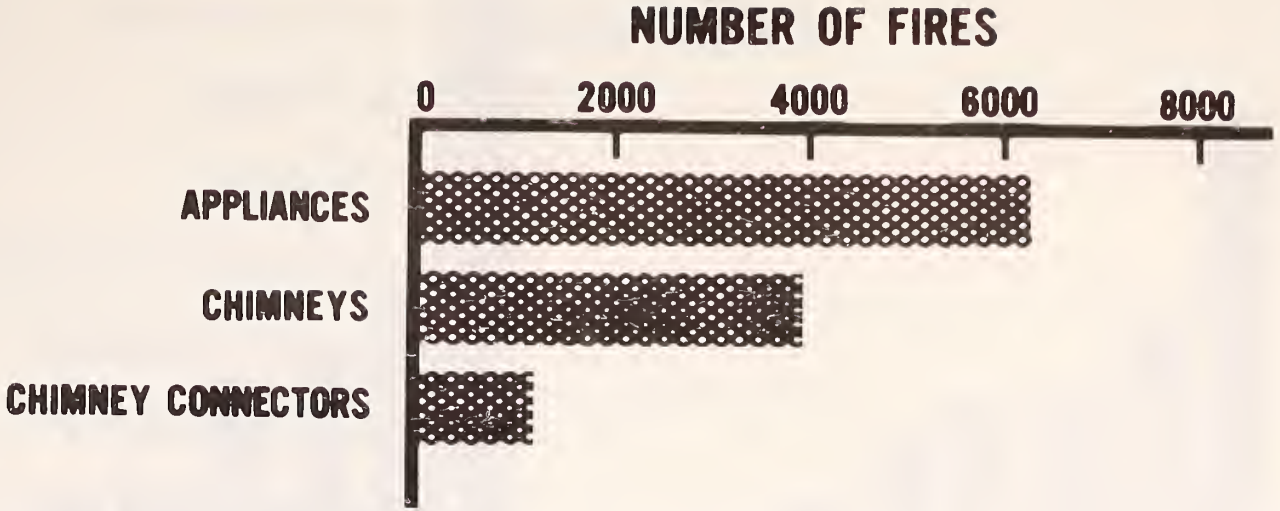

Figure 2. Type of equipment involved as reported in NFIRS solid fuel fire incident data

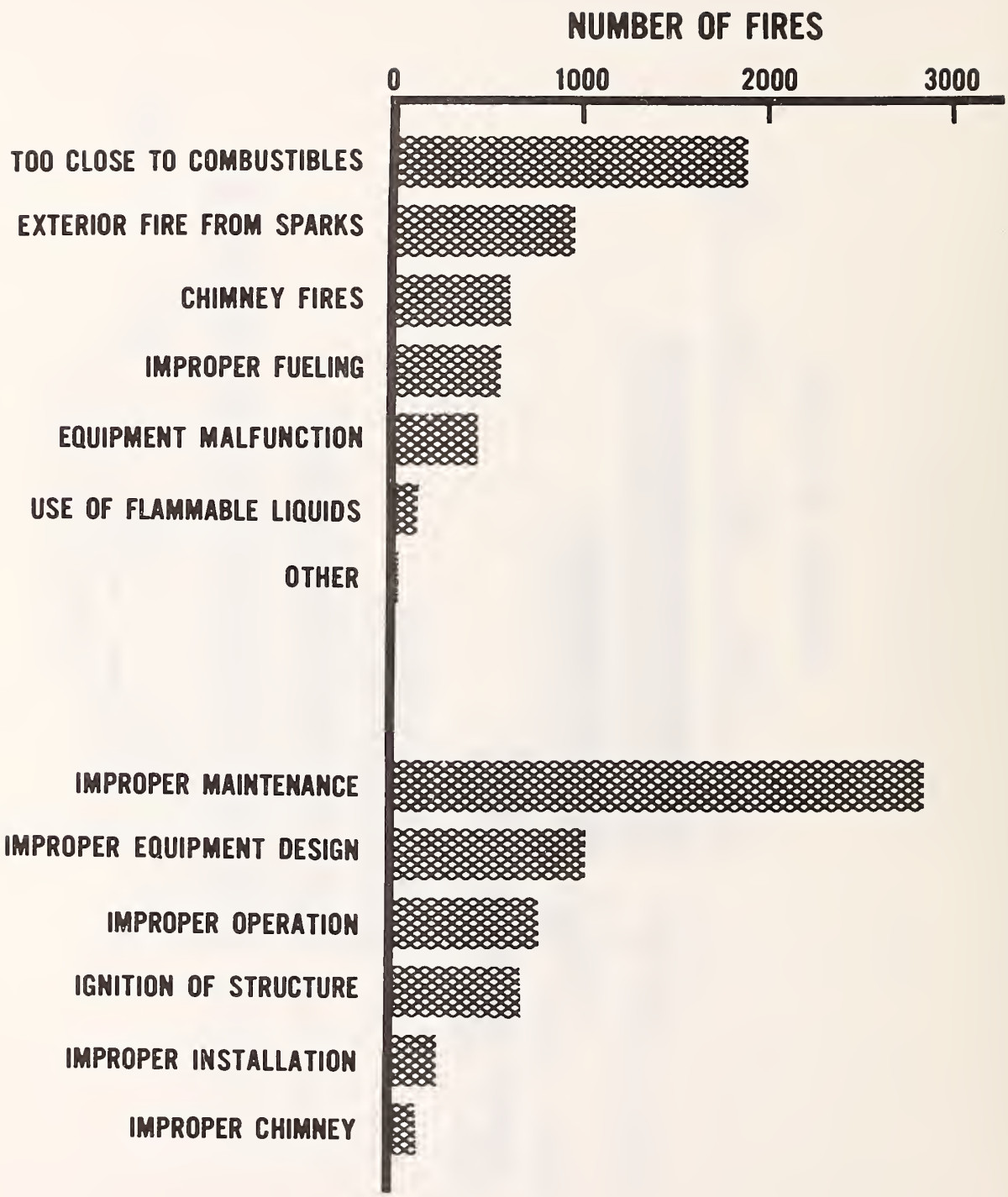

Figure 3. Factors leading to ignition as reported in NFIRS solid fuel fire incident data

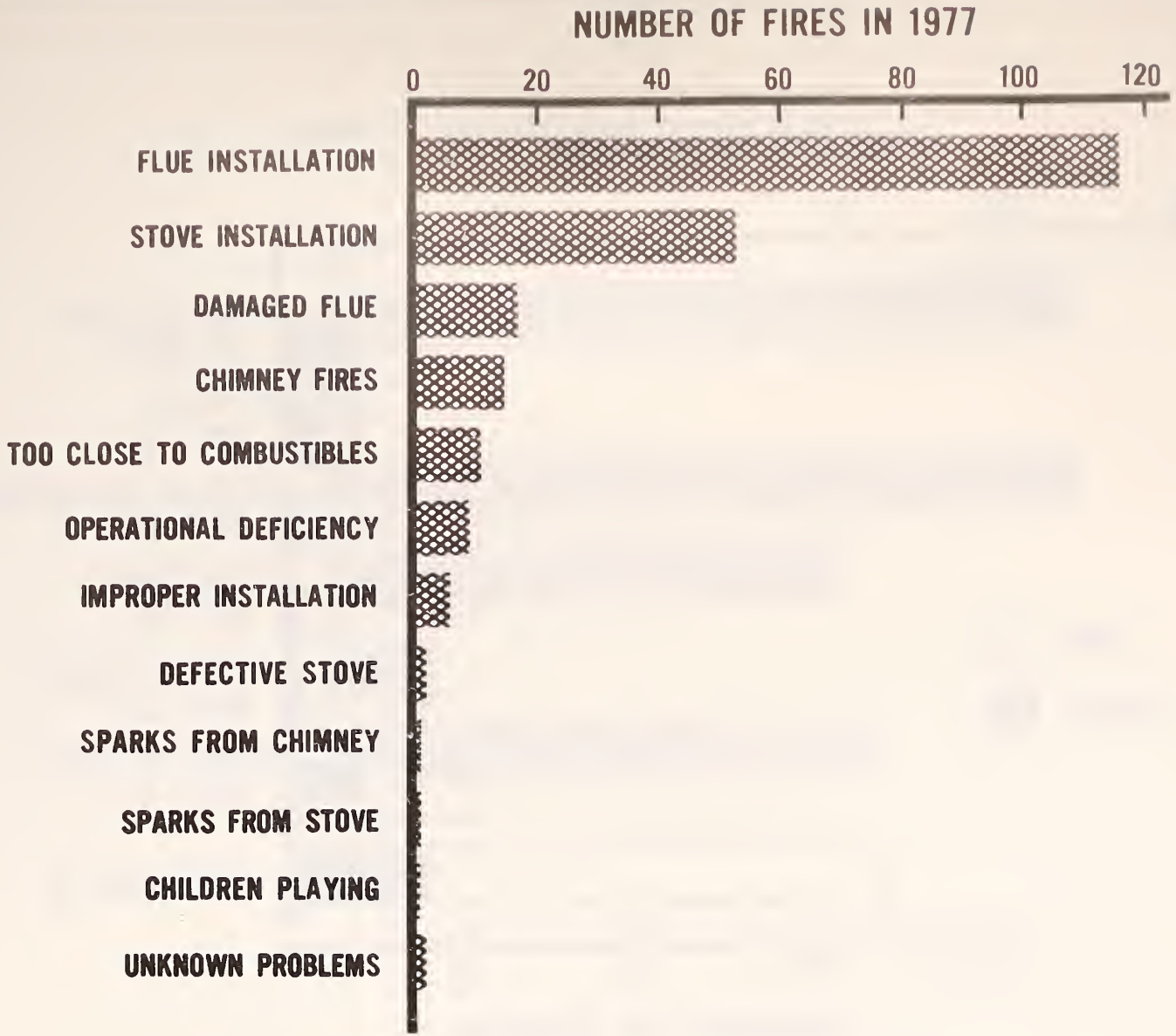

Figure 4. Solid fuel related fire incidents reported to the Oregon State Fire Marshal's Office

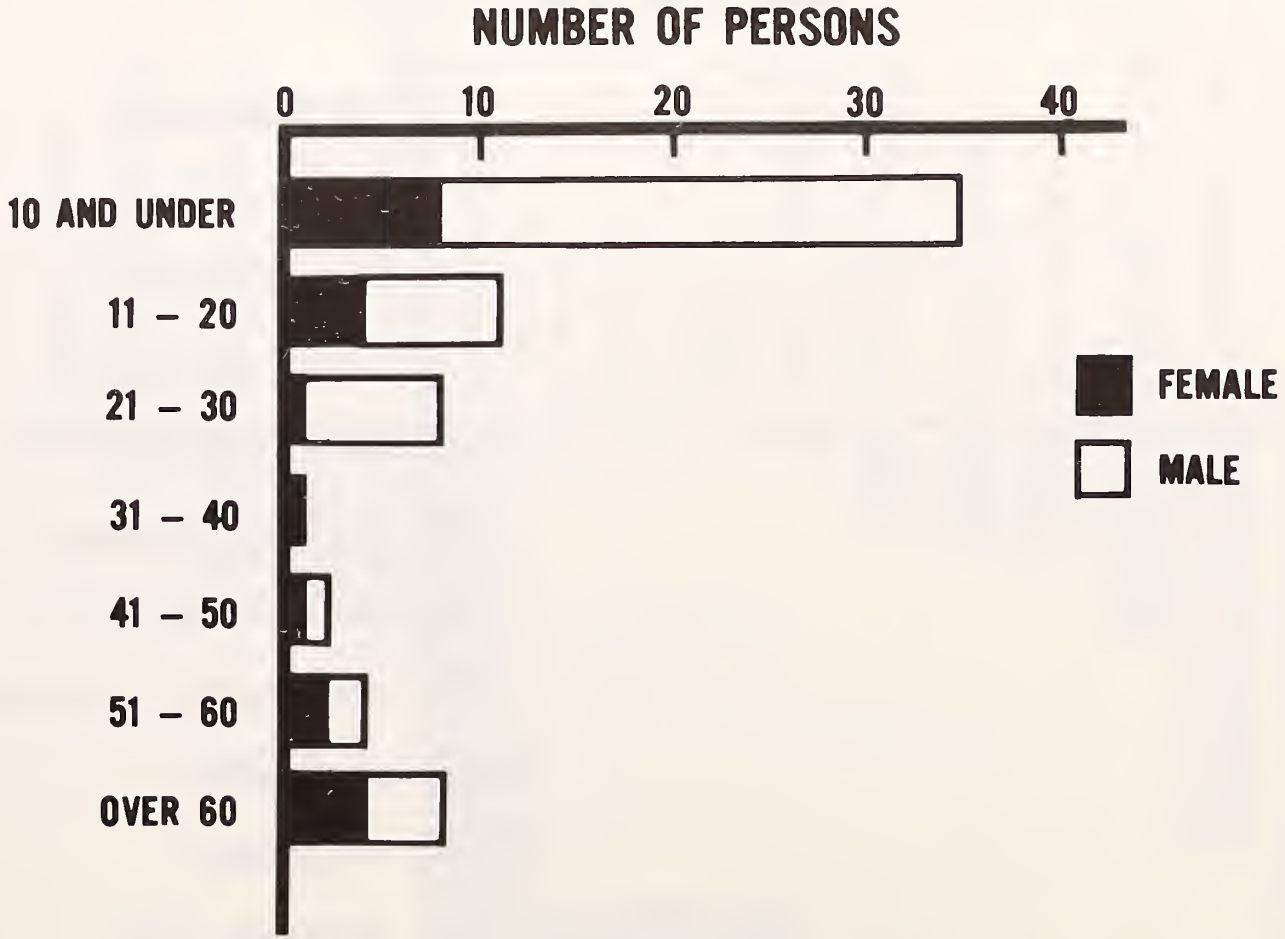

Figure 5. Age and sex of persons injured in wood heating related fires

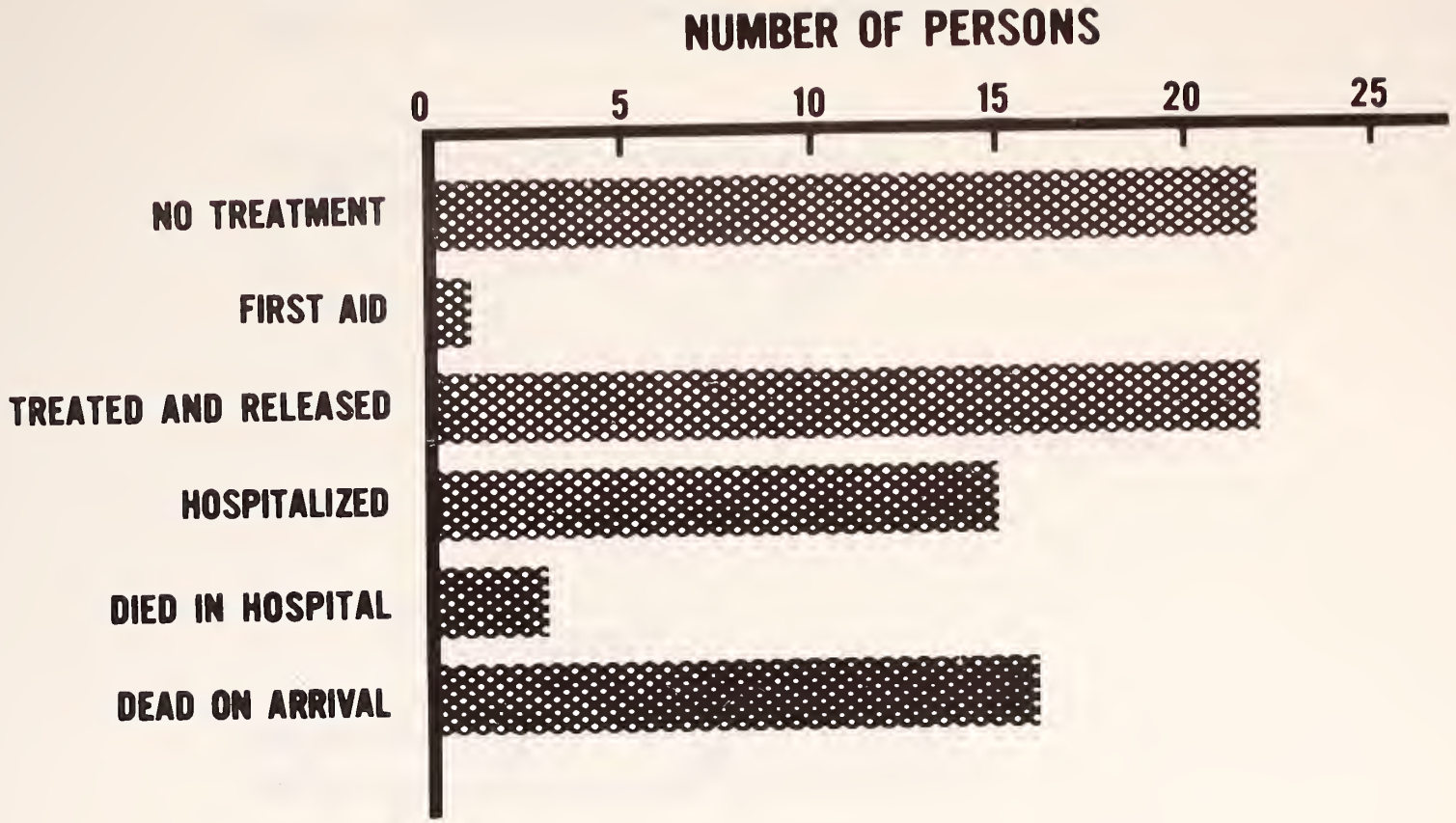

Figure 6. Severity of injury of persons injured in solid fuel related fires

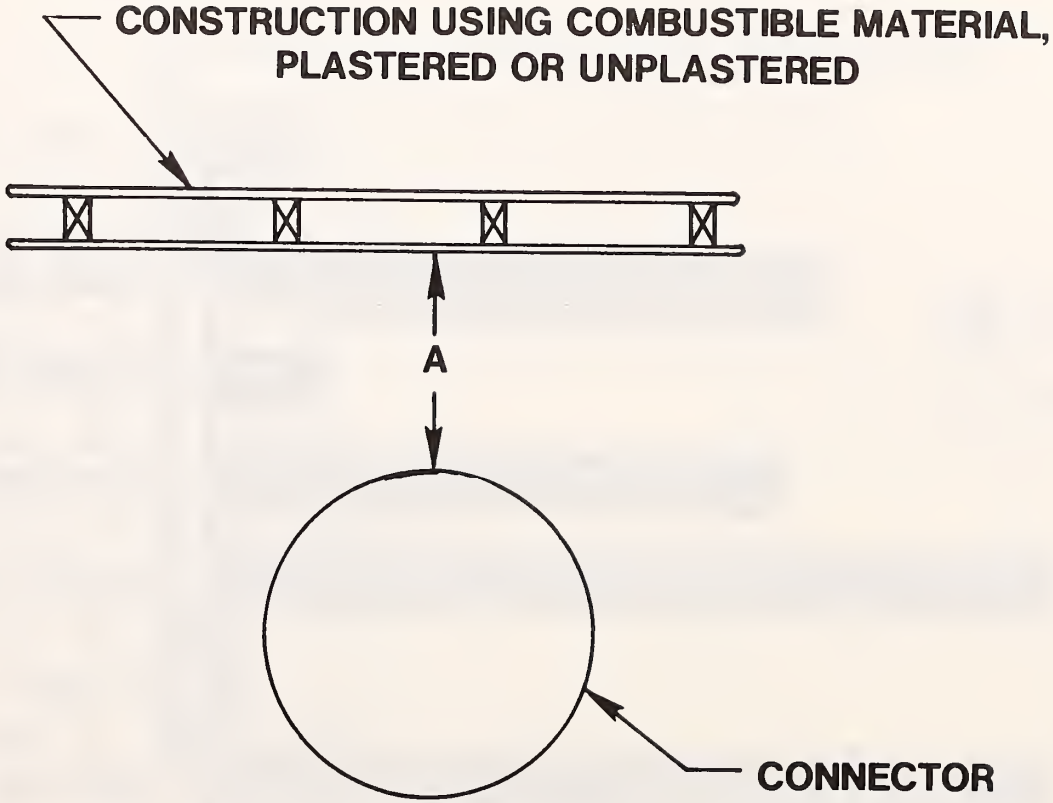

Figure 7. Minimum clearances to heat producing appliances without protection for combustible construction

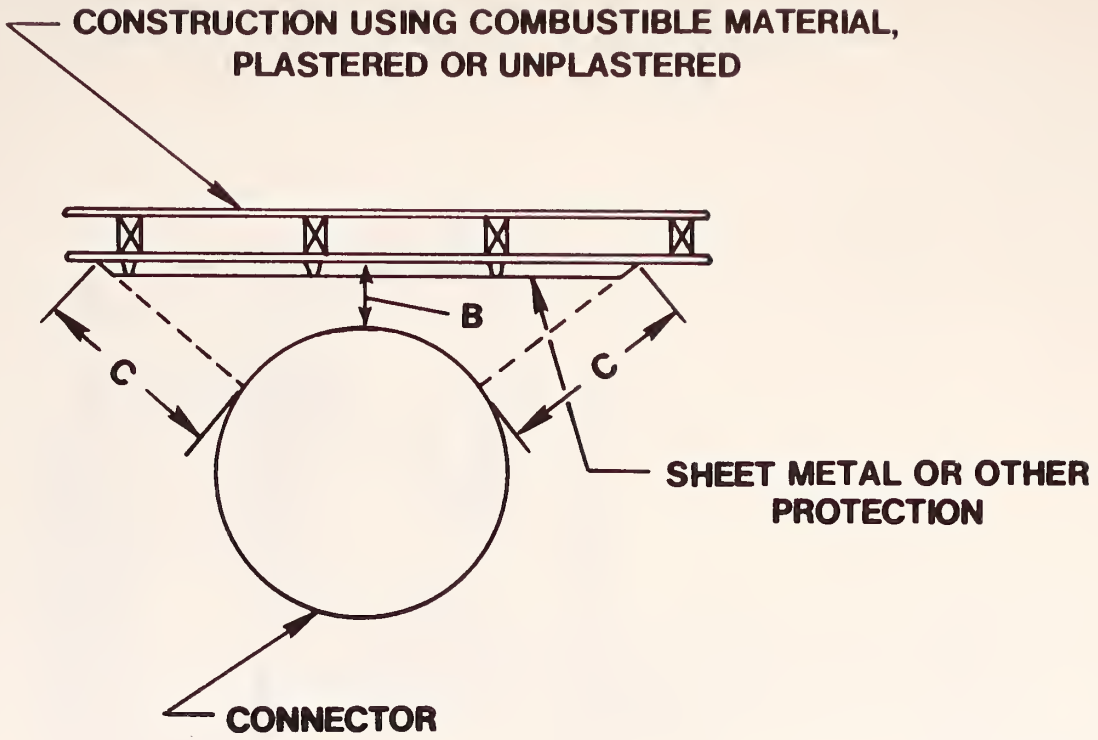

Figure 8. Reduced clearances permitted with specific forms of protection

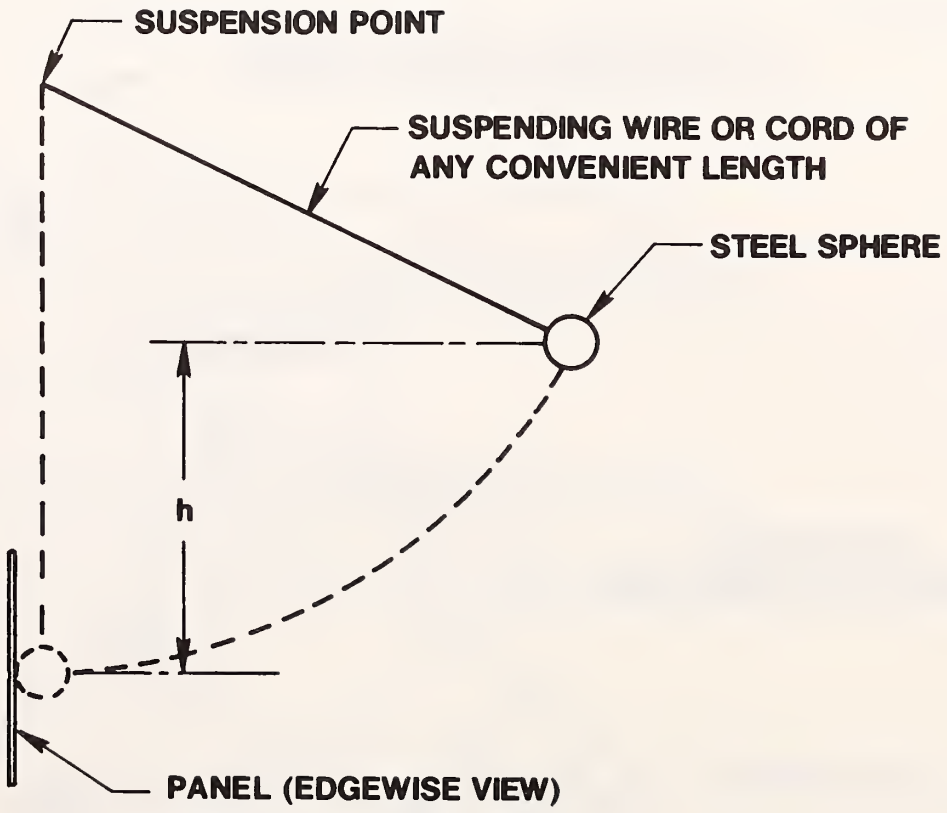

Figure 9. UL 1482 strength test for chimney connector parts

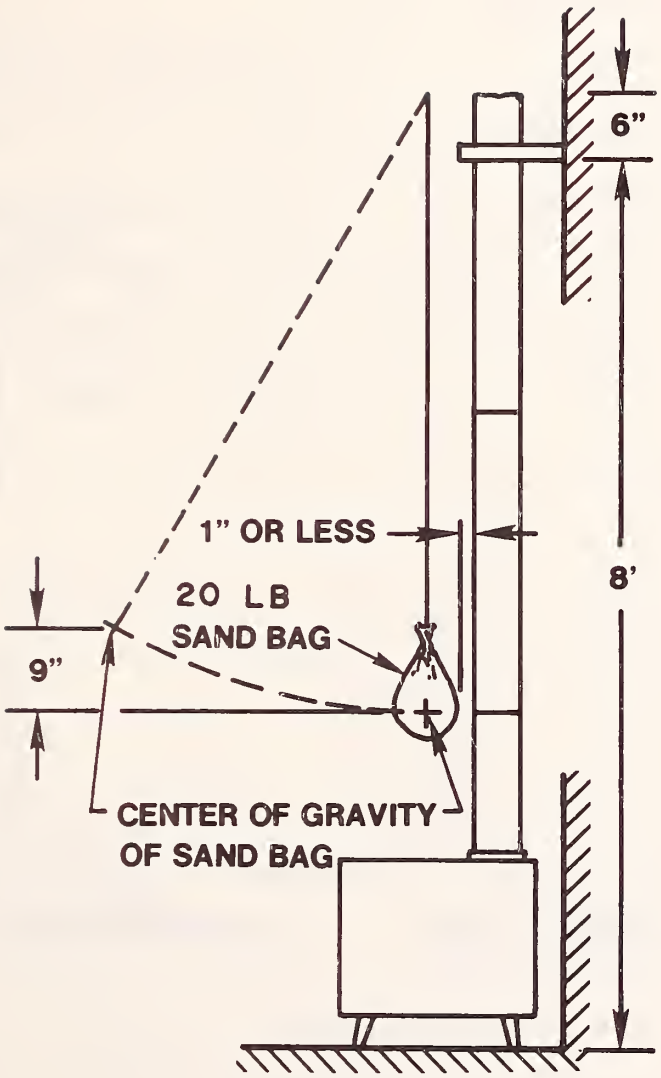

Figure 10. UL 1482 impact test for glazings used as part of doors

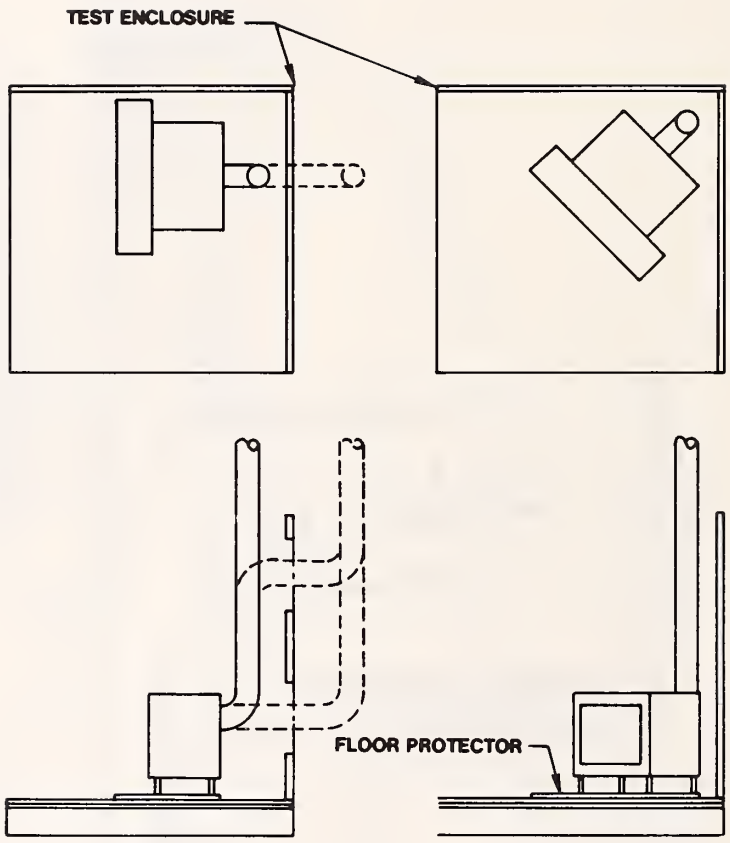

Figure 11. UL 1482 fire test installations

Table 1

Conditions leading to fires attributed to wood-burning equipment

	Number of Fires
Ignition of Combustibles	1,895
Exterior Fire From Sparks	963
Chimney Fires	623
Improper Fueling Technique	578
Equipment Malfunction	457
Use of Flammable Liquids	126
Other	28
Improper Maintenance	2,875
Improper Equipment Design	1,050
Improper Operation	787
Ignition of Structure	702
Improper Installation	248
Improper Chimney	138
Total	10,470

Table 2

Age and sex of persons involved in and causes of accidents related to wood-burning equipment

Activity of Persons Involved/Cause of Accident	Age and Sex of Persons Involved																
	Age Unknown	No Victim	10 And Under		11-20		21-30		31-40		41-50		51-60		Above 60		Totals
			M	F	M	F	M	F	M	F	M	F	M	F	M	F	
Ignition of Combustibles	11	8	8	2			2					1		1	2	1	36
Use of Flammable Liquids	3		3	2	4	3	3	1		1	1		1		1		23
Contact With Hot Surface			5	3	2											1	11
Overheating of Unit		4	7														11
Improper Chimney	6	1															7
Unvented Equipment	6																6
Chimney Fires	2	2													1		5
Ignition of Clothing	1					1	1									2	5
Improper Installation	1	1															2
Product Tipped Over														1			1
Faulty Thermostat		1															1
Other		1	3										1				5
Unknown	5	2	1	1	1		1										11
Totals			27	8	7	4	7	1		1	1	1	2	2	4	4	
	35	20	35		11		8		1		2		4		8		124

Table 3

Severity of injury of persons involved in wood-heating fire accidents

	Wood Burning Equipment[1]	Other Space Heaters[2]	All Space Heaters	Death Certificate File[3]
No Injury	22	8	30	
No Treatment	0	0	0	
First Aid	1	2	3	
Treated and Released	22	10	32	
Hospitalized	15	88	103	
Died while in Hospital	3	11	14	
Dead on Arrival	16	5	21	91
Unknown	1	3	4	

[1] From CPSC NEISS Data 1973-1978.

[2] From Reference [6].

[3] From CPSC Death Certificate File.

Table 4

Model building codes requirements for chimneys

Requirement	BBC	NBC	NFC	SBC	UBC	Details
Masonry Chimneys						
Minimum Wall Thickness	✓	✓	✓	✓	✓	Constructed of solid masonry units or reinforced concrete at least 4 in (10 cm) thick, or rubble stone masonry at least 12 in (30 cm) thick.
Flue Lining	✓	✓	✓	✓	✓	Lined with fire clay flue lining (ASTM C315 or equivalent) at least 5/8 in (1.6 cm) thick.
Multiple Flues	✓	✓	✓		✓	Multiple flues separated by at least 4 in (10 cm) masonry partitions, bonded into the walls of the chimney.
Termination	✓	✓	✓	✓	✓	Extend at least 3 ft (0.9 m) above the highest point where they pass through the roof and at least 2 ft (61 cm) higher than any portion of a building within 10 ft (3 m).
Clearances	✓	✓	✓	✓	✓	At least 2 in (5 cm) from outside face of chimney.

Table 4 (continued)

Model building codes requirements for chimneys

Requirement	BBC	NBC	NFC	SBC	UBC	Details
Factory-Built Chimneys						
Listed Equipment	✓	✓	✓	✓	✓	Factory-made, approved, listed chimneys installed in strict accordance with the terms of the listing.
Zero Clearance				✓		May be installed with zero clearance from wood structural members if testing by recognized testing laboratories indicates the unit does not transmit heat to combustibles more than 90° F above room temperature.
Termination	✓	✓	✓	✓	✓	Same as masonry chimneys.
Clearances	✓	✓	✓	✓	✓	According to the listing.

Table 5

Model building codes requirements for chimney connectors

Requirement	BBC	NBC	NFC	SBC	UBC	Details
Materials of Construction			✓			Made of noncombustible, corrosion resistant material capable of withstanding the flue gas temperatures produced by the appliance.
Minimum Thickness	✓		✓			For unlisted galvanized pipe, minimum thickness ranges from 0.483 mm (26 gauge) for 15 cm (6 in) diameter pipe to 1.473 mm (16 gauge) for 41 cm (16 in) diameter pipe.
Minimum Diameter	✓		✓			Cross sectional area of connector at least as large as the flue collar of the appliance connected to it.
Horizontal Length	✓		✓			Horizontal run less than 75 percent of the vertical height.
Clearance to Combustible	✓		✓			At least 18 in (46 cm) from unprotected surface.
Clearance, Type L	✓		✓			At least 9 in (24 cm) from unprotected surface or according to listing.
Reduced Clearances	✓		✓			Clearance may be reduced to as little as 3 in (7.6 cm) with proper protection of combustible surface.

Table 6

Connector clearances with specified forms of protection[1,2,3,4]

Type of Protection	Where the required clearance with no protection is:			
Applied to the combustible material and covering all surfaces within the distance specified as the required clearance with no protection. Thicknesses are minimum.	36 inches (91.4 cm) (in/cm)	18 inches (45.7 cm) (in/cm)	9 inches (22.9 cm) (in/cm)	6 inches (15.2 cm) (in/cm)
(a) 1/4 in asbestos millboard spaced out 1 in	30/76.2	12/30.5	6/15.2	3/7.6
(b) 0.013" (0.330 mm) sheet metal on 1/4 in asbestos millboard	24/61.0	12/30.5	4/10.2	2/5.1
(c) 0.013" (0.330 mm) sheet metal spaced out 1 in . . .	18/45.7	9/22.9	4/10.2	2/5.1
(d) 0.013" (0.330 mm) sheet metal on 1/8 in asbestos millboard spaced out 1 in	18/45.7	9/22.9	4/10.2	2/5.1
(e) 1/4 in asbestos millboard on 1 in mineral wool bats reinforced with wire mesh or equivalent	18/45.7	6/15.2	4/10.2	2/5.1
(f) 0.027" (0.686 mm) sheet metal on 1 in mineral wool bats reinforced with wire or equivalent	12/30.5	3/7.6	2/5.1	2/5.1

[1] Adapted from reference [13].

[2] Spacers should be of noncombustible material.

[3] Methods (a), (c), and (d) require ventilation between sheet material and protected combustible material. If ventilation may be impaired use method (b), (e), or (f).

[4] Mineral wool bats (blanket or board) should have a minimum density of 8 lb per ft^3 (0.128 g/cc) and a minimum melting point of 1,500° F (816° C).

Table 7

Recommended clearances for horizontal smoke pipe from UL Bulletin of Research 27 [15]

Type of Protection	Clearance With No Protection	
	18 in	9 in
1/2 in plaster	16	7
Sheet metal on asbestos paper	9	2
1/4 in asbestos board spaced down 1 in	8	4
Sheet iron spaced down 1 in	5	2
Sheet metal on 1/4 in asbestos board	4	2
Sheet iron on 1/8 in asbestos spaced down 1 in	4	2
1 in rock wool in sheet metal pan	2	2

Table 8

Model building codes requirements for masonry fireplaces and factory-built wood-burning units

Requirement	BBC	NBC	NFC	SBC	UBC	Details
Masonry Fireplaces						
Minimum Wall Thickness	✓	✓	✓	✓	✓	Structural walls of fireplaces at least 8 in thick when lined with low duty refractory brick, at least 12 in thick without lining.
Fireplace Depth	✓				✓	20 in deep (maximum in UBC).
Firebox Liner			✓	✓		Firebox liner of 1/4 in steel with an air chamber and with back and sides constructed of at least 4 in of solid masonry are permitted.
Hearth Extension	✓	✓	✓	✓	✓	Fireplace is to be equipped with a hearth extension of brick, stone, tile, or other non-combustible material. If fireplace opening is less than 6 square feet, the hearth shall extend at least 16 in, in front of and 8 in on each side. For openings greater than 6 sq ft, 20 in front extension and 12 in side extension are required.

Table 8 (continued)

Model building codes requirements for masonry fireplaces and factory-built wood-burning units

Requirement	BBC	NBC	NFC	SBC	UBC	Details
Clearance	✓	✓	✓	✓	✓	At least 4 in clearance to combustibles and at least 6 in clearance to the fireplace opening. Where walls of the fireplace are at least 12 in thick, facings or trim may be attached directly to the fireplace.
Factory-Built Units						
Listed Equipment	✓	✓	✓	✓	✓	Factory-built, listed, and installed in accordance with the conditions of the listing. Hearth extensions and protection for combustible walls and floors are to be provided according to the manufacturer's instructions.

Table 9

Minimum installation clearances for heat producing appliances, solid fuel type

	Above Top	From Front	From Back	From Sides
Room Heaters				
Circulating Type	36	24	12	12
Radiant or Other Type	36	36	36	36

Table 10

Maximum allowable temperatures on combustible surfaces adjacent to room heaters tested according to UL 1482 [32]

Fire Test	Adjacent Surfaces[1,2]	Flue Gases
Radiant	117°F (65°C)	1,000°F (538°C)[3]
Brand	117°F (65°C)	1,000°F (538°C)[3]
Flash	140°F (78°C)	1,400°F (760°C)[4]

[1] Maximum temperatures apply to surfaces of the test enclosure, of the room heater or chimney connector parts at points of zero clearance to the test structure, and beneath a floor protector.

[2] Temperatures are maximum rises above ambient corrected to 77°F (25°C).

[3] Temperatures may exceed 1,000°F (538°C) but not exceed 1,400°F (760°C) for a cumulative period not exceeding 60 minutes for any 8-hour period of the test.

[4] Temperatures may exceed 1,400°F (760°C) but not exceed 1,700°F (927°C) for a cumulative period not exceeding 10 minutes during the duration of the test.

APPENDIX A

Analysis of Fire Reports on File in the Massachusetts State Fire Marshal's Office Relating to Wood and Coal Heating Equipment

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November, 1978

Notice

This report was prepared for the Center for Fire Research of the National Engineering Laboratory, National Bureau of Standards, under Contract No. NB79NAAA1576. The statements and conclusions contained in this report are those of the author and do not necessarily reflect the views of the National Bureau of Standards or the Center for Fire Research.

Preface

This report was funded by the National Bureau of Standards (NBS), Center for Fire Research (CFR), as a part of the NBS investigation of fire safety of wood-heating equipment sponsored by the Department of Energy.

In this study reports from local fire departments to the Massachusetts State Fire Marshal's Office concerning wood-stove related fires are analyzed for the probable specific cause of the fire. The results may be useful for indicating in which areas preventative actions could be most effective.

Abstract

An analysis of solid-fuel related fires reported by local fire departments to the Massachusetts State Fire Marshal's Office from late 1977 through June, 1978 indicates that of the fires attributed to specific causes, roughly 3/4 were attributed to unsafe installations, and about 1/4 were attributed to unsafe operation/maintenance. In less than 2 percent of the fires was the cause attributed to defects or poor design in the heating appliance itself. Thus, to the extent that the local fire department reports are complete and reliable, it appears that attention to installation, operation and maintenance is what has the most potential for reducing fires.

For approximately the last year, the Massachusetts State Fire Marshal's Office has been keeping a separate file of all solid-fuel-heating related fires reported to the state office by the local fire departments. As of June 1978, there were about 104 reports on file, mostly covering fires which occurred during the 77-78 heating season.

These reports were analyzed for the probable cause of the fire, the objective being to ascertain the percentage of fires attributable to the following three categories of causes: installation (chimneys, chimney connectors, floor protection, clearances, etc.), operation/maintenance, and defects or poor design in the heating unit itself.

The reports themselves appear for the most part, to be cursory. Many local fire departments do not have the expertise and/or time to conduct a thorough investigation. These reports were essentially taken at face value in this analysis.

Of the 104 reported fires relating to wood and coal heating systems, 74 were attributed by the local fire departments to a specific cause; i.e., more specific than "wood stove" or "overfired wood stove." These 74 cases are further broken down in Table 1. Of these 74 cases, 71 percent were attributed to faulty installations, 16 percent were apparently due to poor maintenance (e.g., chimneys not kept clean and furniture and rugs not kept at safe distances from stoves), 11 percent were attributed to operator errors and one single fire was attributed to a "defective stove" with no details given. Since in this fire the house burned to the ground, it is not clear how the determination was made that a defect in the stove caused the fire.

The implication of the sample of reports is clearly that defects and faults in the heaters themselves are not a major cause of fires. The most important area of concern for preventing fires seems to be installations, with operation/maintenance being the other important area.

Table 1.

Reported Cause[1]	No. of Cases	Approximate % of all reported fires	Approximate % of fires for which a usefully specific cause was given
Improper Installations			
not specific	6		
Stove			
not specific	7		
clearances	8		
Stovepipe connector			
not specific	7	53 cases 51%	71%
clearances	9		
joints not fastened	2		
Chimney			
not specific	7		
clearances	3		
cracked chimney	1		
no (or inadequate) liner	3		
Lack of maintenance			
creosote buildup and/or chimney fire	11	12 cases 11%	16%
clearances to furniture not maintained	1		

Table 1. (cont.)

Reported Cause[1]	No. of Cases	Approximate % of all reported fires	Approximate % of fires for which a usefully specific cause was given
Negligent operation			
"Wood shingles drying on top of stove."	1		
"Door may have been left ajar."	1		
"...new mattress... was leaning against the kitchen wall next to a wood stove. Evidently a spark from the stove ignited the mattress, which in turn ignited the rug and floor."[2]	1		
"Possibly started in area where ashes from a wood stove were dumped. Wood ashes stored in a cardboard container."	1	7 cases 7%	11%
"Probable spark from a wood stove igniting combustibles on wall next to stove."[2]	1		
"Spark from wood burning stove ignited overstuffed chair and scorched parlor floor."[2]	1		
"Overheated wood stove and overheated flue pipe. Woman of house filled stove with wood and went to town leaving damper wide open...Stove was very good model and the installations appeared to be very satisfactory. I must believe that this fire was caused by human error other than faulty installation or equipment."	1		

Table 1. (cont.)

Reported Cause[1]	No. of Cases	Approximate % of all reported fires		Approximate % of fires for which a usefully specific cause was given
Defective or unsafe equipment				
"Defective wood stove. Home completely destroyed."	1	2 cases	2%	2%
"Steam explosion of water heating jacket in antique cook stove."[3]	1			
Other (e.g. "Wood stove.")		30 cases	29%	
		104 cases	100%	100%

[1]In cases where 2 or more possible causes were given or implied, I have selected what I consider the more fundamental cause. E.g., one report reads "Overheated chimney connector from wood stove ignited combustible wall." I interpreted this as a case of inadequate clearance between the stovepipe and the wall, since with proper clearances, even overheated stovepipe is very unlikely to ignite combustible walls.

[2]I have assumed sparks got out because a spark screen was not in use when the doors of a Franklin type stove were open. Other interpretations are: 1) inadequate clearances to walls and furnishings, and 2) unsafe stoves which let sparks out with doors shut.

[3]This case might also reasonably be interpreted as due to operator error -- firing up a stove with a capped water jacket with water in it.

Table 1. Fires and other accidents related to the use of wood heating equipment in Massachusetts on file in the State Fire Marshal's Office as of June 26, 1978, covering most of (and mostly) the 1977-78 heating season. The total sample is 104 reports, 74 of which gave usefully specific causes. Determining causes of fires is difficult, particularly when the building is totally destroyed. Many of these local fire department reports are admittedly only educated guesses.

November 10, 1978

TO: Richard Peacock (COTR)
Fire Engineering Safety Division
Center for Fire Research
Room B22, Technology Building
NATIONAL BUREAU OF STANDARDS

FR: B. S. Trant, P.E.
Executive Director
COUNCIL OF AMERICAN BUILDING OFFICIALS

RE: Report on Meeting on Fire-Safety of Wood-Burning Appliances - P. O. #818552

The Council of American Building Officials and the three model code organizations: Building Officials and Code Administrators International, International Conference of Building Officials and Southern Building Code Congress International were pleased to participate in the meeting on Fire-Safety of Wood-Heating Equipment on August 10, 1978. The model code organizations were represented by Chuck Ramani, ICBO; Frank Noonan, BOCA; Robert English, SBCCI and Shep Trant, CABO.

In reviewing the accident survey it revealed that the majority of accidents were caused by faulty installations, such as improper clearance, too close to combustible materials and combustible surfaces, defective chimneys and flues, the use of flammable liquids and overloading of equipment; therefore, it is recommended that minimum installation instructions be developed and included with all wood-burning appliances. Clearances now listed in the codes and standard could be a subject for research. With the increase use of wood-burning appliances in an environment that may be different from that considered in prior tests some of the characteristics may change; therefore, research could be developed to determine the proper clearances from the combustible surfaces and the

reduced clearances that may be available for noncombustible or protected surfaces. Additional areas of research that were identified were:

1. Firing rates and substitutes for wood cribs used as the fuel source in existing test methods;
2. Additional studies into long-term effects of the use of wood products;
3. Improved methods to measure heat;
4. Special hazards that need investigating are:
    a. creosoting;
    b. use of glass doors;
    c. rodent and bird proofing.

Other needs that were identified were the needs of some basic criteria for wood-burning appliances and criteria and instruction for installations since the majority of these units are installed by home-owners rather than by professionals.

The model codes may have some slight variation in their requirements for wood-burning appliances and equipment. The information gathered from research projects would be welcomed by the Board for the Coordination of the Model Codes in order to develop one set of recommended requirments and procedures that could be processed through the code change procedure of the three model codes.

The model code organizations are pleased to have the opportunity to work with the Center for Fire Research on these issues and will make every effort to see that those developments that require action by the model code organizations are carried through the code change process.

Respectfully submitted:

B. S. Trant, P.E.
Executive Director

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15. SUPPLEMENTARY NOTES

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

As a part of the Department of Energy program to advance the technology for the utilization of fuel wood as an alternate energy source for applications ranging from single-family dwellings to apartment complexes and small industries, a review is presented of fire incidents and fire deaths attributable to wood-burning appliances. Initiated to establish accident patterns and to determine the risks involved with the use of wood-burning equipment, the survey represents a compilation of approximately 11,800 fire incidents including injuries and deaths associated with solid fuel burning appliances. In addition, a review of model building codes and of test methods currently used to test or certify wood-burning equipment is included to identify priorities for future research in wood-burning safety.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

Accident investigations; chimneys; coal; creosote; fire departments; fire safety; heating equipment; maintenance; stoves; wood.

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